Atmospheric and remote sensing surveys evaluated at the natural analogue "Campo de Calatrava" and its relation with isotopic Radon activity and CO_2 flux as strategy for CCS projects

Rincones M[1], Ortega M.F.[1], Elío J[2], Gutiérrez del Olmo J[3], Mazadiego L.F.[1], Iglesias L[1], García R[4], García-Martinez M.J.[1]

[1]E.T.S. Ingenieros de Minas. Universidad Politécnica de Madrid (UPM), Madrid, Spain
[2]Fundación Ciudad de la Energía (CIUDEN), Ponferrada, León, Spain
[3]E.T.S. Ingenieros de Agrónomos. Universidad Politécnica de Madrid (UPM), Madrid, Spain
*ma.rincones@upm.es

Abstract

CO_2 capture and storage (CCS) projects are presently developed to reduce the emission of anthropogenic CO_2 into the atmosphere. CCS technologies are expected to account for the 20% of the CO_2 reduction by 2050. The results of this paper are referred to the OXYCFB300 Compostilla Project (European Energy Program for Recover). Since the detection and control of potential leakage from storage formation is mandatory in a project of capture and geological storage of CO_2 (CCS), geophysical, ground deformation and geochemical monitoring have been carried out to detect potential leakage, and, in the event that this occurs, identify and quantify it. This monitoring needs to be developed prior, during and after the injection stage. For a correct interpretation and quantification of the leakage, it is essential to establish a pre-injection characterization (baseline) of the area affected by the CO_2 storage at reservoir level as well as at shallow depth, surface and atmosphere, via soil gas measurements.

Nonetheless, CO_2 flux can also be produced from natural aerobic respiration and can mask early, low-intensity leakage. Consequently, it results convenient to monitor other gases whose concentration can be related to deep sources. Therefore, the methodological approach is important because it can affect the spatial and temporal variability of this flux and even jeopardize the total value of CO_2 in a given area. The Campo de Calatrava was selected as a natural analogue for this research because of its particular characteristics, being the most important the presence of several gas and water discharges that are distributed throughout the area.

In this order of ideas, a measurement protocol has been established using portable infrared analyzers (i.e., accumulation chambers) adapted to monitoring of geological storage of CO_2, and other measurements of trace gases, e.g. radon/thoron (radon is probably the most natural tracer used to detect faults and fractures). However, it is necessary to compare different measurement techniques to assess potential differences between them and consider which one(s) offer the most reliable response to the objectives of the various stages of a project of geological storage of CO_2.

On the other hand, multispectral and hyperspectral imagery was used to study remote sensing techniques. The first sets of data were provided by two satellite images, over an enlarged area of interest. Both have different source satellites and dates. The other set of data is provided by two hypersepectral airborne images acquired by Aerospatiale Technologies National Institute (INTA) in June 2011, by means of the AHS and CASI1500 airborne sensors. At the time of acquisition of the hyperspectral images, in situ spectral signature were obtained over different land covers.

Before analyzing the images, it was necessary to perform a preprocessing method which included geometric, radiometric, topographic and atmospheric adjustments. The final product is an image of the area with the absolute reflectance in digital values. Two different approaches for image analyses were carried out:

(i) Generation, correlation and analysis of vegetation indices from satellite images. Vegetation Indices are usually referred to specific bands or wavelengths. As a consequence, it is possible that a certain vegetation index cannot be obtained starting from imagery if the required bands are missing. In this case, ten and six vegetation indices were obtained from WorldView-2 and QuickBird imagery, respectively. These vegetation indices have been generated in three areas where a bigger concentration of CO_2 leak hop-spots is present.

(ii) Correlation of hyperspectral images and spectral signatures obtained in situ. A spectral signature is the combination of electromagnetic energy emitted, absorbed and/or reflected at varying wavelengths for a given material. This means that a land cover can be identified and mapped if its spectral signature is known. On this basis, the following technique is proposed to achieve the goal of identifying CO_2 leakage hot-spots applying the cross correlogram spectral matching technique.

Some of the results generated, assume that in areas with point-source releases of CO_2, such as the volcanic area of Campo de Calatrava, a positive correlation between high CO_2 fluxes and radon (^{222}Rn and ^{220}Rn) activities was observed, suggesting that CO_2 is behaving as the main carrier gas. Also, the image analysis techniques indicate that some vegetation indices for the detection of diffuse emissions of CO_2 can successfully be applied. Thus, a correlation between some of the vegetation indices and CO_2 flux and radon activity were indeed recognized.